Theory of mind and the Ultimatum Game in healthy adult aging

Theory of mind and the Ultimatum Game in healthy adult aging

Alessandra Girardi, Sergio Della Sala and Sarah E. MacPherson

Centre for Cognitive Ageing and Cognitive Epidemiology and Human Cognitive Neuroscience, Department of Psychology, University of Edinburgh, UK

Word count: 4,147 words

Address correspondence to:
Sarah E. MacPherson
Human Cognitive Neuroscience
Department of Psychology, PPLS
University of Edinburgh
7 George Square
Edinburgh, UK
EH8 9JZ
Tel: ++44 (0)131 650 9862
E-mail: sarah.macpherson@ed.ac.uk

INTRODUCTION

The Ultimatum Game is commonly used to examine decision-making involved in social interactions (Güth, Schmittberger, & Schwarze, 1982). Participants are instructed that one player will propose to split a certain amount of money with them (e.g., £10). The participants (i.e., the respondents) can choose to either accept or reject the offer. If the respondent accepts the offer (e.g., £8: £2), the money will be split as proposed; if instead the respondent rejects the offer, both players will get nothing. Typically, when the respondent is offered 20%-30% of the total amount, the offers are rejected and rejection rates increase as offers become more "unfair" (Güth et al., 1982; Nowak et al., 2000). It has been proposed that humans incorporate social norms into their decision-making and reject unfair offers even when it conflicts with their own self-interest (Knoch, Pascual-Leone, Meyer, Treyer, & Fehr, 2006).

The concept of inferring others' mental states such as their beliefs, desires and intentions, known as Theory of Mind (ToM; Premack & Woodruff, 1978), has been proposed as being fundamental for cooperative relationships with others (Sanfey, Civail, & Vavra, 2015). Performance on the Ultimatum Game is thought to rely on spontaneous ToM as the task involves an interactive social situation involving economic decision-making where individuals should consciously adopt the subjective point of view and intentions of the proposer in relation to oneself (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003; Shamay-Tsoory, Suleiman, Aharon-Peretz, Gohary, & Hirschberger, 2012). For example, Shamay-Tsoory et al. (2012) introduced a "greedy" condition in the Ultimatum Game where the proposer chose between slightly unfair and very unfair options, in an attempt to encourage individuals to attribute unfair, greedy intentions to the proposer. Shamay-Tsoory and colleagues

found that "greedy" intentions were associated with the highest rejection rates in healthy individuals.

Developmental studies involving children have also provided evidence that ToM plays an important role as a mediator of fairness behaviour in the Ultimatum Game (Sally & Hill, 2006; Takagishi, Kameshima, Schug, Koizumi, & Yamagishi, 2010; Takagishi et al., 2014). Takagishi and colleagues (2010) demonstrated that preschool children whose ToM had developed divided sweets more fairly than those whose had not. In another study involving stickers as incentives, Takagishi et al. (2014) demonstrated that the ability to understand another person's mental state in preschool and school-age children had a positive influence on the number of stickers offered and a small negative effect on the rejection of unfair offers.

While the ability to understand another person's mental states plays an important role in the Ultimatum Game in children and younger adults, to our knowledge, no study has investigated whether ToM performance is related to Ultimatum Game performance in older adults. The few studies that have investigated the effect of age on Ultimatum Game performance have produced contradictory results. Some studies have found that the rejection of low and unfair offers increases as people become older (Beadle et al., 2012; Roalf, Mitchell, Harbaugh, & Janowsky, 2012). Higher rejection rates of unfair offers in older adults has been associated with higher levels of cognitive empathy (Beadle et al., 2012). In other studies, however, while no overall age difference in rejection rates was found, younger adults rejected significantly more unfair offers made by younger compared to older proposers (Bailey et al., 2012). Harlé and Sanfey (2012) demonstrated that younger and older adults had similar acceptance rates for fair ($5 out of $10) and the most unfair ($1–$2 out of $10) offers but older adults accepted significantly fewer moderately unfair offers (i.e.,

$3 out of $10). Finally, a study of individual differences revealed that there was not a relationship between age and acceptance rates for fair or unfair offers (Nguyen et al., 2011). However, these previous studies have not considered that differences in the rejection rates of unfair offers in previous studies may be explained by ToM abilities, as individuals who reject unfair offers are thought to be focusing on the interpersonal component of the task (Handgraaf, van Dijk, Wilke, & Vermunt, 2003).

The literature concerning older adults' ability to understand the mental states of others has produced conflicting results. Several studies report poorer ToM abilities in older compared to younger adults (e.g., Bailey, Henry, & Von Hippel, 2008; Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006; see Henry, Phillips, Ruffman, & Bailey, 2013 for a recent meta-analysis). Other studies have reported that older adults perform as well or even better than younger adults (Happé, Winner, & Brownell, 1998; MacPherson, Phillips, & Della Sala, 2002). The few aging studies that have considered performance on more than one ToM task in the same group of younger and older adults have reported age-related differences on some tasks, but not others (Castelli et al., 2010; Li et al., 2012), suggesting that there is not a general decline in ToM abilities with age.

As far as we know, no studies have examined ToM abilities and their influence on Ultimatum Game performance within the same group of older adults. Given that better ToM abilities have been found to result in greater rejection rates of "unfair" offers in children and young adults (Shamay-Tsoory et al., 2012; Takagishi et al., 2014), it is proposed that those older adults who perform better on ToM tasks will perform more poorly on the Ultimatum Game and accept fewer "unfair" offers. We administered two theory of mind tasks thought to assess affective and cognitive aspects of ToM: the Faux Pas task (Stone, Baron-Cohen, & Knight, 1998) which

assesses ToM based on complex verbal abilities; and the Judgment of Preference task (Shamay-Tsoory & Aharon-Peretz, 2007; Girardi, MacPherson, & Abrahams, 2011; van der Hulst, Bak, & Abrahams, 2015) which assesses ToM but involves minimal language abilities.

METHODS

Participants

Twenty-two younger adults (3 men, 19 women) aged 18-23 years (M = 19.55, SD = 1.6) and 30 older adults (9 men, 21 women) aged 60-81 years (M = 69.77, SD = 6.6) were recruited for the study. The younger and older groups did not significantly differ in terms of their years of full-time education (M = 14.23, SD = 1.7 and M = 14.37, SD = 2.2 respectively), $t(50) = -.24$, $p = .81$. All participants performed the Addenbrooke's Cognitive Examination-Revised (ACE-R; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006) to assess overall cognitive abilities and the vocabulary and reasoning subtests from the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) to assess intellectual abilities. The younger and older participants did not significantly differ in their ACE-R score out of 100 (M = 95.68, SD = 2.64 and M = 96.13, SD = 3.13 respectively), U = 376.50, z = .87, $p = .38$, and no participant performed below the cut-off of 82 indicating dementia. In addition, the two age groups did not significant differ in terms of their full-scale IQ (M = 117.09, SD = 6.6 and M = 118.43, SD = 6.9 respectively), $t(50) = -.700$, $p = .49$. The younger participants were undergraduate Psychology students who received course credits for participating in the study while the older participants were recruited through the panel of volunteers at the Department of Psychology, University of Edinburgh and were reimbursed for any expenses incurred. English was the first language of all

participants. None of the participants had any self-reported history of neurological or psychiatric disorders. The study was approved by the Psychology Department Research Ethics Committee at the University of Edinburgh and written informed consent was obtained from all participants.

Materials and Procedure

Theory of Mind Tasks

Faux Pas task. The Faux Pas task consisted of 10 faux pas stories and 10 non-faux pas stories (Stone et al., 1998). In the faux pas stories, participants were read stories in which someone said something that would hurt or offend another character in the story. The non-faux pas stories described a social situation in which no faux pas had occurred. The stories remained in front of the participants whilst being read and during the subsequent questions. After each story, participants were asked to respond orally whether someone in the story said something they should not have said (a maximum of 10 points for faux pas stories and a maximum of 10 points for non-faux pas stories). If a faux pas was detected, participants were asked a further four questions to determine whether they understood who committed the faux pas, the mental state of the character experiencing the faux pas, the mental state of the character who delivered the faux pas and why it was inappropriate (a maximum of 40 points). An empathy question was also asked to determine whether participants understood that the person who experienced the faux pas would be hurt or offended by it (a maximum of 10 points). A control question relating to details of the story but which did not require reference to the characters' mental states was also asked (a maximum of 10 points).

Judgement of Preference task. The Judgement of Preference task assesses the ability to make a preference judgment based on eye gaze and was based on the tasks adopted by Girardi et al. (2011) and Shamay-Tsoory and Aharon-Peretz (2007). Each trial involved a cartoon face presented in the middle of the computer screen looking at one of four objects belonging to the same semantic category (e.g., animals, fruits). Each corner of the computer screen contained one of the four objects (see Figure 1). The participant's task was to indicate which object the character was referring to based on a statement at the top of the screen and available cues (e.g., eye gaze direction). Participants performed four randomly presented first-order conditions: *physical* where participants stated which item the cartoon face was close to; *look at* where participants indicated which item the face was looking at based on his eye gaze; *affective* where the character's facial expression provided affective information and participants had to respond to the picture that the cartoon face loved; and *cognitive* where the character's face was emotionally neutral and participants had to respond to the picture that it was thinking of. Then there were four randomly presented second-order conditions where cartoon faces were presented next to each of the semantically-related items and participants had to understand the interaction between the main cartoon face and the other character: *physical* where participants indicated which item both cartoon faces possessed; *look at* where participants indicated which item both cartoon faces were looking at; *affective* which relies on understanding the main character's emotions in relation to the other character's emotions and so participants indicated which item both cartoon faces loved; and *cognitive* which relies on understanding the main character's beliefs and desires about the other character's beliefs and desires and so participants indicated which item both cartoon faces were thinking of. Participants responded by pressing one of four buttons

on the keyboard that corresponded to the four corners on the computer screen. In the physical and look at conditions, there were 8 trials and in the affective and cognitive conditions, there were 12 trials. Participants were instructed to respond as quickly but as accurately as possible. The proportion of correct responses was computed for each condition with a maximum score of 1 for each one.

- Insert Figure 1 around here -

The Ultimatum Game. Participants acted as responders during a series of trials in which a fictitious player, an opponent, made an economic offer via the computer. The identity of the opponent was represented by a photograph of an individual's face displayed on the computer screen with their name. The 8 different opponents (4 female, 4 male) were emotionally neutral faces taken from the NimStim Face Stimulus Set (Tottenham et al., 2009). The task consisted of six types of offer each repeated 8 times, once by each female opponent and once by each male opponent (48 offers in total). The offers consisted of splitting £10 between the participant and the opponent. Half of the offers were considered fair (opponent: participant = £4: £6, £5: £5, £6: £4) and half were considered unfair (opponent: participant = £9: £1, £8: £2, £7: £3). Participants were told they could accept or reject the offer by pressing the corresponding button on the keyboard. If accepted (e.g., £6: £4), the money would be divided as stated (the opponent would get £6, the participant would get £4). If rejected, both players would receive nothing. After the response, a final slide was presented for 3 seconds showing the outcome for that offer (e.g., "You rejected the offer. You both get nothing."). The offers were presented pseudo-randomly, no

information about the fictitious opponents was provided and participants were not actually paid the money for the accepted offers.

Subjective ratings of fairness and anger for each type of offer. After completing the Ultimatum Game, participants were presented with the six types of offer made during the game. For the fairness ratings, they indicated how fair or unfair they perceived each offer on a 5-point Likert scale (1 = very unfair; 5 = very fair). For the subjective emotional responses, they indicated on a separate 5-point Likert scale how angry they felt after each offer type (1 = not angry; 5 = very angry).

RESULTS

For all post-hoc analyses, a p-value of 0.01 was applied in order to reduce the chance of type I error.

Theory of Mind Tasks

Faux Pas task. As the data were not normally distributed, the performance of the two age groups in terms of faux pas accuracy, non-faux pas accuracy and the empathy questions were analyzed using Mann Whitney U-Tests (see Table 1). The analyses indicated that older adults did not perform more poorly than younger adults in terms of accuracy on the faux pas stories or the faux pas empathy scores ($p > .21$). Non-faux pas story accuracy was not significantly different in younger and older adults, $U = 224.50$, $z = -2.41$, $p = .02$. The performance on the faux pas control questions was at ceiling in both age groups, therefore the results were not further analysed. A Mann-Whitney U-Test on the non-faux pas control stories did not reveal any significant difference between younger and older participants ($p = .24$).

Judgement of Preference task. As performance on the first-order condition was close to ceiling in both age groups, only the second-order judgement of preference scores are considered (see Table 1). The performance of the two age groups on each condition was compared using Mann-Whitney U-Tests. Further separate analyses for each age group were conducted using the Wilcoxon signed-rank test to compare performance across the conditions.

Mann-Whitney U-Tests demonstrated no significant differences between the two age groups in the look at (p = .76), affective (p = .33) or cognitive (p = .84) conditions. There was a trend for younger participants to perform better than older participants on the physical condition although this was not significant, U = 211.0, z = -2.39, p = .02. The subsequent Wilcoxon signed-rank test analyses revealed that the older adults performed significantly more poorly on the physical compared to the look at condition, Z = -3.68, p < .001, whereas the younger participants performed similarly in the two conditions (p = .22). None of the other comparisons were significant.

- Insert Table 1 around here -

The Ultimatum Game

The mean acceptance rates and standard errors of the mean for each offer for the younger and older participants are reported in Figure 2. The acceptance rates were analysed separately for each type of fair and unfair offer using a logistic regression fitted with generalised estimating equations. The analysis demonstrated a significant main effect of offer type, χ^2 (5) = 745.68, p < .001. Post-hoc pairwise comparisons showed that all fair offers were accepted significantly more than the unfair offers (all

p values < .001). No difference emerged in the acceptance rate of two of the fair offers (£4: £6 and £5: £5), which were both accepted more than the third fair offer (£6: £4, both *p* values < .001). The unfair offer £7: £3 was accepted significantly more than both the remaining unfair offers ($p < .001$ and .005 for £9: £1 and £8: £2 respectively). No significant difference was found between the acceptance rates of the £8: £2 and £9: £1 unfair offers.

- Insert Figure 2 around here -

There was also a significant main effect of age group, χ^2 (1) = 76.65, $p < .001$, with older adults accepting more offers ($M = 64.72$; $SD = 26.13$) than younger participants ($M = 51.61$; $SD = 12.49$). The group x type of offer interaction was also significant, χ^2 (4) = 35.45 $p < .001$. Post-hoc pairwise comparisons showed that the unfair £9: £1 offer was accepted significantly more often by older participants than younger participants ($p < .01$), while the two age groups exhibited a similar acceptance rate for all fair offers and the unfair £8: £2 and £7: £3 offers. Further post-hoc comparisons showed that younger adults accepted all three fair offers significantly more than the unfair offers (all *p* values < .001). No significant difference emerged in the acceptance rates of the fair offers and in the acceptance of the unfair offers in younger participants. Similarly, older participants accepted all fair offers significantly more than the unfair offers (£9: £1 compared to £6: £4, $p < .005$; all other comparisons $p < .001$). No significant difference emerged in the acceptance of the unfair offers and in the acceptance of any of the three fair offers in older participants.

Subjective ratings of fairness for each type of offer. The mean fairness ratings for each offer was examined using Mann-Whitney U-Tests. The analysis showed that the two age groups did not significantly differ in their subjective ratings of fairness for any fair ($p > .17$) or unfair offer ($p > .07$).

Subjective ratings of anger for each type of offer. Mann-Whitney U-Test analysis showed that the two age groups did not significantly differ in their subjective ratings of anger for any fair ($p > .18$) or unfair offers ($p > .02$).

- Insert Table 2 around here -

The Faux Pas task and Judgment of Preference task data provide little variance in younger and older adults to conduct correlational analyses. Therefore, associations between Ultimatum Game performance and the ToM tasks were not examined. However, separate Spearman correlation coefficients were calculated for each age group between the acceptance rates for fair and unfair offers and ratings of fairness and anger on the Ultimatum Game. In younger adults, there was a significant positive correlation between the acceptance rates for the unfair offers and ratings of fairness, $r = 0.46$, $p < .05$, where the higher the ratings of fairness, the higher the acceptance rates for unfair offers. In the older participants, no correlations were significant ($p > .05$).

To test whether the correlations across age groups were significantly different from one another, Fisher's Z-transformations were then calculated. The significant correlation between the acceptance rates for the unfair offers and ratings of fairness in

younger adults was significantly different to the older adults' correlation, $Z = 2.30$, $p < .05$.

DISCUSSION

In the current study, while no age difference emerged for the acceptance rates for fair offers, older participants accepted more unfair offers than younger adults, accepting significantly more of the most unfair offers (i.e., 9:1) compared to younger adults. This age difference is unlikely to be due to perceived feelings of unfairness, as the two age groups did not significantly differ in their fairness ratings. In fact, both younger and older adults' subjective ratings of fairness decreased in the same downward trajectory as the offers became more unfair. These findings suggest that older adults' judgments of fairness were intact (i.e., they realise offers were unfair) but they are willing to consider and accept these unfair offers more than younger adults. While younger adults also realised that offers were unfair, this did influence their acceptance offers, with fewer unfair offers being accepted.

In terms of perceived anger, there was a trend for older adults to feel less angry about unfair offers than younger adults, which may underlie their willingness to accept more of these offers. However, limited statistical power due to our modest sample size (N = 52: younger = 22 and older = 30) may have limited the significance of some of the statistical analyses carried out. A post-hoc power analysis conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) revealed that our sample size would detect large effects (d=0.8) with 80% power with alpha at .05. There was less adequate statistical power at the small or medium effect size level. Moreover, given that previous research has not found age-related differences in anger ratings for

unfair offers (Bailey et al., 2012), this interpretation should be considered with caution.

Another aim of the study was to investigate whether an increased understanding of other people's intentions influences Ultimatum Game performance in healthy younger and older adults. It was hypothesised that older adults who perform better on ToM tasks would accept fewer unfair offers. However, we did not find age-related differences in the ToM abilities of our younger and older adults, as there was little variance between younger and older adults' performance on the Faux Pas task or the Judgement of Preference task. Therefore, the hypotheses relating to these ToM measures could not adequately be tested. In a recent meta-analysis, Henry et al. (2013) reported that ToM abilities were significantly poorer in older adults compared to younger adults, regardless of the type of ToM task administered. However, some types of ToM tests included the meta-analysis involved only a small number of cases. Moreover, some research including our own, has not found age differences on ToM tasks including the Faux Pas task (MacPherson et al., 2002), ToM stories (Happé et al., 1998) and the Judgment of Preference task (Castelli et al., 2010). For a review of the influence of age on individual ToM tests, see MacPherson and Della Sala (2015). Future work might examine whether alternative measures of ToM are associated with older adults' performance on the Ultimatum Game.

Some of the contradictory findings in the aging literature relating to the Ultimatum Game might be due to differences in the ratio of fair and unfair offers. In the current study where unfair offers were accepted more by older adults than younger adults, an equal ratio of fair and unfair offers were made. Other studies that have reported no age differences or where older adults have rejected significantly more

unfair offers than younger adults, unequal numbers of fair and unfair offers have been presented (Beadle et al., 2012; Nguyen et al., 2011; Roalf et al., 2012).

Task instructions and incentives may have also influenced the motivation to accept monetary offers. Previous research has shown that younger and older participants tend to reject more unfair offers when they play with proposers via a computer interface and no particular emphasis was placed on the reality of the situation (Roalf et al., 2012). Yet, Beadle et al. (2012)'s older adults also rejected more unfair offers using a more naturalistic design where they were led to believe they were playing against the same proposer using a speakerphone. This may have led their older adults to feel the need to make it clear to their proposer that they would not accept unfair treatment. Our participants were told that they were to play a game but neither the reality of the situation nor whether their response to one proposer would affect subsequent offers were emphasised and a manipulation check was not made to ascertain whether participants actually believed they were playing against individuals. Pointing out that responses would not affect future offers may encourage older adults to reject offers more easily, especially when payment is guaranteed regardless (Roalf et al., 2012). Differences in the incentives offered at the end of the Ultimatum Game may have also influenced performance. Some studies inform their participants that they will earn an additional amount of money depending on their performance (e.g., Bailey et al., 2012; Roalf et al., 2012) while others do not (e.g., Beadle et al., 2012). The majority of our younger participants received course credits for participating while older individuals were reimbursed financially, independently of the outcome. Different incentives may have motivated our younger and older adults to perform the Ultimatum Game in different ways.

In summary, subjective ratings of fairness did not significantly differ between younger and older adults. However, while younger adults followed the offer values of "fair" versus "unfair", rejecting more of the unfair offers, older adults accepted more unfair offers than younger adults. These findings imply that older adults are more rational in their behavior, accepting unfair offers as it is in their self-interest to accept even small monetary values compared to receiving nothing. Future work should examine whether this greater acceptance of unfair offers in older adults is associated with poorer ToM, using tasks that offer more of a challenge to healthy younger and older adults.

REFERENCES

Bailey, P. E., Henry, J. D., & Von Hippel, W. (2008). Empathy and social functioning in late adulthood. *Aging & Mental Health, 12(4),* 499-503. http://dx.doi.org/10.1080/13607860802224243

Bailey P. E., Ruffman, T., & Rendell, P. G. (2012). Age-related differences in social economic decision making: the ultimatum game. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 68(3),* 356-363. http://dx.doi.org/10.1093/geronb/gbs073

Beadle, J. N., Paradiso, S., Kovach, C., Polgreen, L., Denburg, N. L., & Tranel, D. (2012). Effects of age-related differences in empathy on social economic decision-making. *International Psychogeriatrics, 24(5),* 822-833. http://dx.doi.org/10.1017/S1041610211002547

Castelli, I., Baglio, F., Blasi, V., Alberoni, M., Falini, A., Liverta-Sempio, O., Nemni, R., & Marchetti, A. (2010). Effects of aging on mindreading ability through the eyes: an fMRI study. *Neuropsychologia, 48(9),* 2586-2594. http://dx.doi.org/10.1016/j.neuropsychologia.2010.05.005

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175-191. http://doi:10.3758/BF03193146

Girardi, A., MacPherson, S. E., & Abrahams, S. (2011). Deficits in emotional and social cognition in Amyotrophic Lateral Sclerosis. *Neuropsychology, 25(1),* 35-65. http://dx.doi.org/10.1037/a0020357

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior and Organization, 3(4),* 367-388. http://dx.doi.org/10.1016/0167-2681(82)90011-7

Handgraaf, M. J. J., van Dijk, E., Wilke, H. A. M., & Vermunt, R. C. (2003). The salience of a recipient's alternatives: inter- and intrapersonal comparison in ultimatum games. *Organizational Behavior and Human Decision Processes, 90,* 165-177. http://dx.doi.org/10.1016/S0749-5978(02)00512-5

Happé, F. G., Winner, E., & Brownell, H. (1998). The getting of wisdom: theory of mind in old age. *Developmental Psychology, 34(2),* 358-362. http://dx.doi.org/10.1037/0012-1649.34.2.358

Harlé, K. M., & Sanfey, A. G. (2012). Social economic decision-making across the lifespan: An fMRI investigation. *Neuropsychologia, 50(7),* 1416-1424. http://dx.doi.org/10.1016/j.neuropsychologia.2012.02.026

Henry, J. D., Phillips, L. H., Ruffman, T., & Bailey, P. E. (2013). A meta-analytic review of age differences in theory of mind. *Psychology and Aging, 28(3),* 826-839. http://dx.doi.org/10.1037/a0030677

Keightley, M. L., Winocur, G., Burianova, H., Hongwanishkul, D., & Grady, C. L. (2006). Age effects on social cognition: Faces tell a different story. *Psychology and Aging, 21(3),* 5585-5572. http://dx.doi.org/10.1037/0882-7974.21.3.558

Knoch, D., Pascual-Leone, A., Meyer, K., Treyer, V., & Fehr, E. (2006). Diminishing reciprocal fairness by disrupting the right prefrontal cortex. *Science, 314(5800),* 829-832. http://dx.doi.org/10.1126/science.1129156

Li, X., Wang, K., Wang, F., Tao, Q., Xie, Y., & Cheng, Q. (2012). Aging of theory of mind: The influence of educational level and cognitive processing.

International Journal of Psychology, 48(4), 715-727. http://dx.doi.org/10.1080/00207594.2012.673724

MacPherson, S. E., & Della Sala, S. with Cox, S. R., Girardi, A., & Iveson, M. H. (2015). *Handbook of Frontal Lobe Assessment.* Oxford: Oxford University Press. http://dx.doi.org/10.1093/med:psych/9780199669523.001.0001

MacPherson, S. E., Phillips, L. H., & Della Sala, S. (2002). Age, executive function, and social decision making: a dorsolateral prefrontal theory of cognitive aging. *Psychology and Aging, 17(4),* 598-609. http://dx.doi.org/10.1037/0882-7974.17.4.598

Mioshi, E., Dawson, K., Mitchell, J., Arnold, R., & Hodges, J. R. (2006). The Addenbrooke's Cognitive Examination Revised (ACE-R): a brief cognitive test battery for dementia screening. *International Journal of Geriatric Psychiatry, 21,* 1078-1085. http://dx.doi.org/10.1002/gps.1610

Nguyen, C. M., Koenigs, M., Yamada, T. H., Teo, S. H., Cavanaugh, J. E., Tranel, D., & Denburg, N. L. (2011). Trustworthiness and negative affect predict economic decision making. *Journal of Cognitive Psychology, 23(6),* 748-759. http://dx.doi.org/10.1080/20445911.2011.575773

Nowak, M. A, Page, K. M., & Sigmund, K. (2000). Fairness versus reason in the ultimatum game. *Science, 289(5485),* 1773-1775. http://dx.doi.org/10.1126/science.289.5485.1773

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a "theory of mind?". *Behaviour and Brain Sciences, 4,* 515-526. http://dx.doi.org/10.1017/S0140525X00076512

Roalf, D. R., Mitchell, S. H., Harbaugh, W. T., & Janowsky, J. S. (2012). Risk, reward and economic decision-making in aging. *Journals of Gerontology,*

Series B, Psychological Sciences and Social Sciences, 67(3), 289-298. http://dx.doi.org/10.1093/geronb/gbr099

Sally, D., & Hill, E. (2006). The development of interpersonal strategy: Autism, theory-of-mind, cooperation, and fairness. *Journal of Economic Psychology, 27,* 73-97. http://dx.doi.org/10.1016/j.joep.2005.06.015

Sanfey, A. G., Rilling, J. K., Aronson, J., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the Ultimatum Game. *Science, 300(5626),* 1755–1758. http://dx.doi.org/10.1126/science.1082976

Sanfey, A. G., Civail, C., & Vavra, P. (2015). Predicting the other in cooperative interactions. *Trends in Cognitive Sciences, 19(7),* 364-365. http://dx.doi.org/10.1016/j.tics.2015.05.009

Shamay-Tsoory, S. G., & Aharon-Peretz, J. (2007). Dissociable prefrontal networks for cognitive and affective theory of mind: a lesion study. *Neuropsychologia, 45(13),* 3054-3067. http://dx.doi.org/10.1016/j.neuropsychologia.2007.05.021

Shamay-Tsoory, S.G., Suleiman, R., Aharon-Peretz, J., Gohary, R., & Hirschberger, G. (2012). Sensitivity to fairness and intentions of others in the ultimatum game in patients with ventromedial prefontal lesions. *Journal of the International Neuropsychological Society, 18(6),* 952-961. http://dx.doi.org/10.1017/S1355617712001257

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10(5),* 640-656. http://dx.doi.org/10.1162/089892998562942

Takagishi, H., Kameshima, S., Schug, J., Koizumi, M., & Yamagishi, T. (2010). Theory of mind enhances preference for fairness. *Journal of Experimental*

Child Psychology, 105, 130-137. http://dx.doi.org/10.1016/j.jecp.2009.09.005

Takagishi, H., Koizumi, M., Fujii, T., Schug, J., Kameshima, S.,, & Yamagishi, T. (2014). The Role of Cognitive and Emotional Perspective Taking in Economic Decision Making in the Ultimatum Game. *PLoS ONE, 9(9),* e108462. http://dx.doi.org/10.1371/journal.pone.0108462

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research, 168(3),* 242-249. http://dx.doi.org/10.1016/j.psychres.2008.05.006

van der Hulst, E. J., Bak, T. H., & Abrahams, S. (2015). Impaired affective and cognitive theory of mind and behavioural change in amyotrophic lateral sclerosis. *Journal of Neurology, Neurosurgery, & Psychiatry, 86(11),* 1208-2015. http://dx.doi.org/10.1136/jnnp-2014-309290

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence (WASI).* The Psychological Corporation: Harcourt Brace & Company. New York, NY.

Table 1

Medians and ranges for the total correct on the faux pas and non-faux pas stories and the proportion of correct responses on the Judgement of Preference conditions in the younger and older groups.

	Younger Median (range)	Older Median (range)
Faux Pas Task		
Faux pas accuracy (max = 40)	36.00 (18-39)	36.50 (27-40)
Faux pas empathy (max = 10)	9.00 (5-10)	9.00 (3-10)
Faux pas control questions (max = 10)	10.00 (10-10)	10.00 (10-10)
Non-faux pas accuracy (max = 10)	10.00 (9-10)	10.00 (5-10)
Non-faux pas control questions (max = 10)	10.00 (9-10)	10.00 (5-10)
Judgement of Preference Task		
Physical	1.00 (0-1)	0.80 (0.1-1)
Look at	1.00 (0.5-1)	1.00 (0.2-1)
Affective	0.90 (0.7-1)	0.90 (0.8-1)
Cognitive	0.90 (0.5)	1.00 (0.3-1)

Table 2

Median and score ranges for fairness and anger judgements for each type of offer provided by younger and older participants.

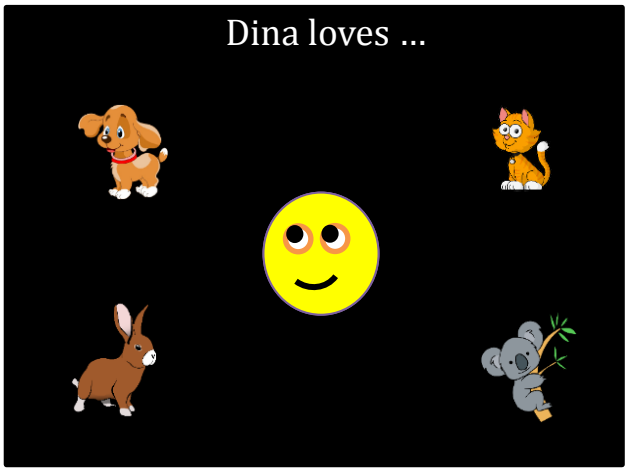
	Fairness		Anger	
	Younger	Older	Younger	Older
	Median (range)	Median (range)	Median (range)	Median (range)
£4: £6	3.00 (2-5)	3.00 (1-5)	1.00 (1-3)	1.00 (1-3)
£5: £5	5.00 (3-5)	5.00 (3-5)	1.00 (1-3)	1.00 (1-3)
£6: £4	3.00 (1-5)	3.00 (1-5)	2.00 (1-4)	2.00 (1-4)
£7: £3	2.00 (1-4)	2.00 (1-5)	3.00 (2-4)	2.00 (1-4)
£8: £2	2.00 (1-3)	1.00 (1-5)	4.00 (1-5)	3.00 (1-5)
£9: £1	1.00 (1-3)	1.00 (1-5)	4.00 (1-5)	3.00 (1-5)

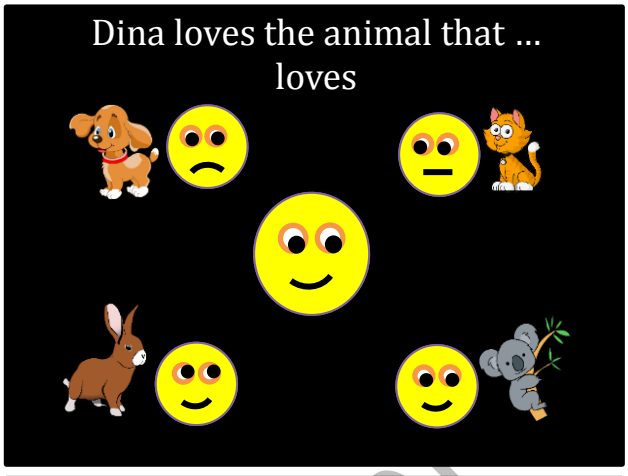
Higher scores indicate higher fairness/anger reported. Maximum = 5.

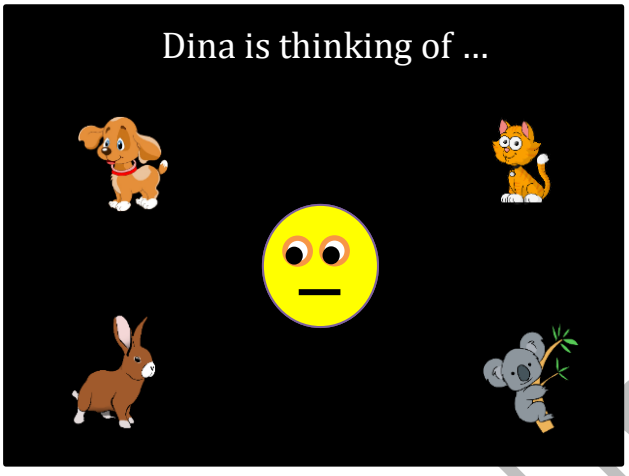
Figure Captions

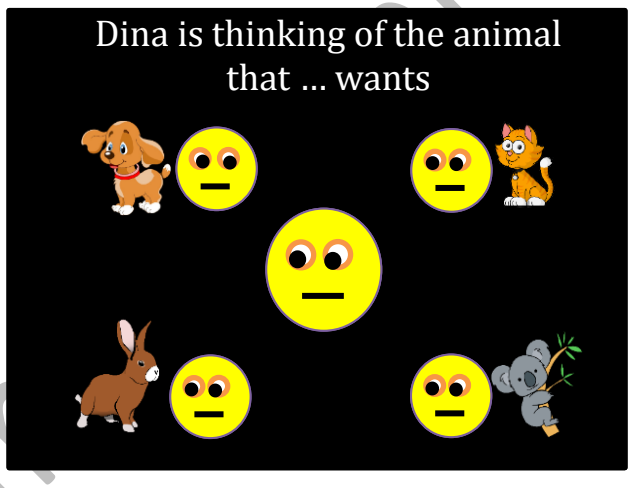
Figure 1. Examples of first-order and second-order trials. Top left: Affective first order; Top right: Affective second order; Bottom left: Cognitive first order; Bottom right: Cognitive second order

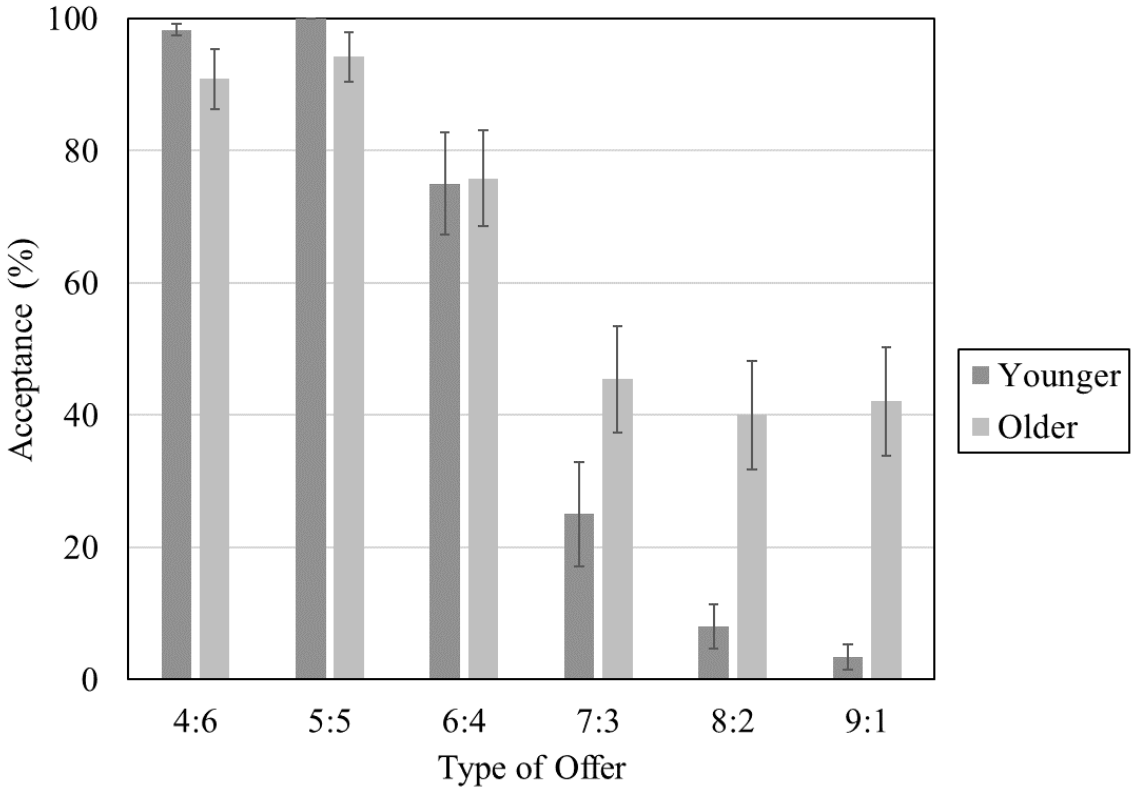
Figure 2. Mean percentage acceptance rates with standard errors of the mean (SE) for each offer in the younger and older groups.


Dina loves ...


Dina loves the animal that ... loves


Dina is thinking of ...


Dina is thinking of the animal that ... wants


100
80
60
40
20
0
Acceptance (%)
4:6
5:5
6:4
7:3
8:2
9:1
Type of Offer
Younger
Older